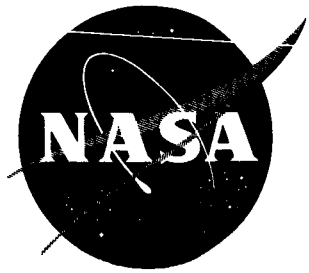
NASA TN D-68



TECHNICAL NOTE

D-68

GENERAL-PURPOSE SUBROUTINES FOR THE IBM 650 MAGNETIC DRUM DATA-PROCESSING MACHINE WITH ATTACHMENTS

By Vearl N. Huff, Don N. Turner, and Oliver W. Reese

Lewis Research Center
Cleveland, Ohio

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SUMMARY

A set of routines has been designed for use with SOAP II and basic-language programming for the IBM 650 Magnetic Drum Data-Processing Machine equipped with floating decimal arithmetic, immediate access storage, and indexing accumulators.

The package is 528 words long. It is capable of calculating certain transcendental and arithmetic functions common to most engineering problems. Three reading and two punching routines using two common formats are provided. A console-controlled trace, bypassing package subroutines, is included. Available also is a 38-word program designed to condense 1-word-per-card SOAP II output to five words per card.

Execution times of the routines are somewhat less than those for comparable routines in the 650 Bell interpretive system. Execution times of the floating point operations vary between 1/5 and as little as 1/30 of the corresponding Bell commands.

INTRODUCTION

Two IBM 650 computers have been in use at the NASA Lewis Research Center since 1956. Since most of the calculations were of the engineering type, a floating decimal notation was found advantageous. Successful use was made of the Bell interpretive system for this purpose. It was apparent that addition of certain attachments to the basic 650 would increase the speed and efficiency of computation. Accordingly, floating decimal arithmetic, high-speed core storage, and indexing registers were installed in 1957. To take advantage of the increased speed without loss of flexibility or convenience, a new set of routines was devised.

With the experience gained using the Bell system, the contents and general structure of the new "package" were established. Prime considerations were flexibility, speed, ease of use, and compactness. The

over-all system, known as the "653 Rocket Package," is an integrated program occupying 528 words of storage. Its purpose is to provide for the programmer (1) certain commonly used mathematical operations (i.e., sine, cosine, arctangent, logarithm, antilogarithm, and square root), (2) easy-to-use input-output procedures, and (3) effective and economical means for locating program errors by use of a console-controlled trace.

The package is used at Lewis in conjunction with SOAP II, but use in basic language is equally feasible. In view of this, all references to machine instructions throughout this report will be both in SOAP II mnemonic form and in basic language.

SOAP II

For the benefit of those who are not familiar with Symbolic Optimal Assembly Programming (SOAP), a brief description follows.

The programmer who has no access to an assembly program such as SOAP II must manually assign locations to instructions and data while writing the program. If the calculations are to be executed as fast as possible, it is also necessary to assign these locations very carefully, in accordance with some sort of optimum programming chart.

In order to relieve the programmer of this task, SOAP II was devised by S. Poley of IBM. It requires only a basic 650 with an alphabetic device. This assembly program automatically, and optimally, assigns storage locations to instructions and data. If one wishes to refer to a particular location while writing a program, a "name" of not more than five letters or numbers or a combination thereof may be given this location. SOAP II then assigns absolute storage locations to these names (mnemonic designations), when put through the 650 on an assembly or "SOAPing" pass prior to program running.

For example, to calculate X+3, the basic-language program might be

LOC	OP	D	I
1252	60	0757	1262
1262	10	0767	1272

where all locations have been assigned by the programmer. In SOAP II programming, one could write

LOC	OP	D	I
	RAU	X	
	AUP	THREE	

where the absolute locations of instructions X and THREE will be optimally assigned by the assembly process.

To connect orders that are not in sequence, corresponding I-addresses and locations are given a name. "AUP" is the standard alphabetic designation for the "10" operation. Similar type mnemonic triples are used for the other operations.

Apart from the advantage of being able to write an entire program by using mnemonic combinations to indicate machine operations and the location of data and instructions, the most important feature of SOAP II is the automatic assignment of storage locations (either named or unnamed by the programmer) in a manner to produce near maximum speed in program execution.

Details of this assembly program have been published in IBM Form 32-7646-1, "SOAP II Programmer's Reference Manual."

GENERAL DESCRIPTION OF PACKAGE

Location and Number of Storages

The package uses 528 drum locations (1472-1999), including one read band, two punch bands, and one five-word table. Up to a maximum of 20 core locations are used at various times and are not restored to their original content. All three indexing registers are used, but in all cases the prior contents of these registers are preserved and restored by the package. (Appendix A is a one-word-per-card listing of the package in SOAP II output form, with various title and comments cards.)

Card Formats

It was arbitrarily decided that two card formats should be available to the user of this package. The first is the familiar six-word, serially stored Bell card. The other is called the "Random location" card. This card can contain as many as five words, each with its particular location. There are several obvious advantages to this format, particularly when used as input. Both formats may be used at any time either for input or output. (Appendix C shows the detailed contents of these cards, and appendix G gives board wiring details.)

Contents of Package

The package contains five transcendental routines (sine, cosine, arctangent, logarithm, antilogarithm) and a square-root routine.

A loading routine is provided that will accept SOAP II output cards (self-loading), Bell cards, and Random location cards. They may be intermixed. Loading stops if either a Bell transfer or load hub card is read. Provision is made for reading Bell cards after computation has begun or for returning to the original loading routine.

Two reading routines are available for Bell cards. One stops if the card read is not headed for the right location. The other ignores such a card and reads subsequent cards until it finds the right one.

There are two output routines, one for each card format. In addition, the machine "Punch" (71) operation may be used to obtain both these formats or load-hub cards, depending on the contents of word 10 of the punch band.

All these routines with their mnemonic and absolute drum entries, length, and execution times are listed in appendix B.

In addition to these routines, provision for tracing has been made. By proper console switching, the problem may be stopped at any point and put in trace mode for any number of instructions. Package routines are not traced unless desired, in which case a one-word modification in the package must be made. Trace output is in modified Bell format. Punching rate is 100 cards per minute, the limit of the 533 punch unit.

Operating instructions are given in appendix I.

USING THE PACKAGE

Assume that a problem is ready to program; the sequence of steps in determining a solution is clearly established, and a flow diagram has been made. It is now necessary to know how to enter the package routines.

Package Entry

Entering into and exiting from any routine is very simple, since only one order is required. This order is of the form

```
LDD aaaa SQRT
(69 aaaa 1750)
```

where the first row is SOAP II mnemonic language and the second is basic language. With the argument in the upper accumulator, this instruction will cause the program to enter the package, find the square root of the argument, and execute the next instruction from "aaaa." Before entering

functional routines, the argument must be in the upper accumulator. Since the results of all floating point operations are in this location, this is a logical requirement. For similar reasons, results of all package routines are left in the upper accumulator.

This simplified one-word entry is made possible by use of the conventional linkage; that is, the first instruction of each package routine is of the form

STD LINK bbbb
(24 1503 bbbb)

where "bbbb" is the next command in the routine to be executed. Therefore, an entry of the type illustrated (69 aaaa 1750), called the "linkage," will cause the instruction located at "aaaa" to be transferred to "LINK" in the package routine. After completing the routine, control is then sent to "LINK" (1503) for executing the next instruction ("aaaa").

Loading

The package is loaded by means of the loading routine given in appendix D.

The standard console setting "70 1951 1998" will load (1) the package, (2) load-hub cards, (3) Bell cards, or (4) Random location cards. When the latter two are read, control is transferred to the package loading routine at 1998. In addition, the following routine is provided for loading either Bell or Random location cards: LOAD (1950). This routine will continue loading until either (1) a Bell transfer card is read, or (2) a basic load hub card is read. LOAD is different from 1998 only in that it does not reset the indexing accumulators. SOAP II output cards will load; but, if a nonload hub card follows, control will transfer to 1998.

Reading

Two reading routines are available, both for Bell format only. They are used for reading after execution of the program has begun.

(1) RD CK (1900). The "Read and Check" routine imitates the Bell read command. A "key" word must first be put into the lower accumulator to specify the location of the first word to be read and the number of words to be read. If the location on the card (columns 6 to 9) does not agree with the location specified by the key word, a stop "01 0002 1896" occurs. If the location agrees but the word count (column 10) is too large, a stop "01 0003 1897" occurs.

For example, if 30 words are to be read, beginning at location 1234, after which the instruction at location ABCD is to be executed, one would write:

```
RAL KEY
LDD ABCD RD CK

KEY 00 1234 0030  (key word)
```

or, in basic language,

```
     65 cccc bbbb
bbbb 69 ABCD 1900

cccc 00 1234 0030  (key word)
```

The upper accumulator must be clear at entry. The routine restores it to this condition at exit.

If one writes the preceding orders with the key word

```
KEY 00 3234 0030
(bbbb 00 3234 0030)
```

the contents of indexing accumulator A will be added to location "1234" before execution. Location "3234" must be punched on the card or a stop will occur, because the comparison is made before indexing. If indexing accumulator A contains 0030, the 30 words will be read into locations 1264 to 1293.

A Bell transfer card will be ignored if the location checks, and the location will remain the same for the next card.

(2) RD LK (1920). The "Read and Look" routine is similar to the "Read and Check," except that, if the location does not check, it reads another card, repeats the test, and continues until it finds either (1) a card with the location as specified, or (2) a load hub card, in which case control is transferred out of the routine.

If the word count punched on a card of correct location is greater than the number of words remaining to be read, this routine loads only the number needed and then continues. This routine will not ignore extra words at the beginning of a card and pick up the correct locations from the following words. Bell transfer cards are ignored.

(NOTE: All three indexing accumulators may be used in setting up an entry into either "RD CK" or "RD LK," since none are used internally by these routines.)

Punching

Two routines are provided for output, one for Bell format, the other for Random location cards.

(1) PUNCH (1930). The "Punch" routine imitates the Bell command in punching Bell cards. Entry is similar to the two reading routines described. A control for tabulator spacing may also be specified in the key word (digit position 9).

The lower accumulator again contains a key word, or specification, indicating (1) tabulator spacing control (which will appear in column 80 of the first card punched), (2) location of the first word, and (3) number of words to be punched.

(NOTE: A possible arrangement for tabulator spacing control is given in appendix H.)

For example, the program

```
      RAL  SPEC
      LDD  ABCD  PUNCH
SPEC  06   9000  0055
```

or, in basic language,

```
       65  gggg  ffff
ffff   69  ABCD  1930
gggg   06  9000  0055
```

will punch core from 9000 to 9054. The first output card will contain a "6" punch in column 80, for tabulator control.

A location referring to an indexing accumulator will be modified by the accumulator before obtaining the data. The location punched on the card is unmodified.

(2) RMPCH (1940). The Random Punch routine is similar to the PUNCH, except that it punches Random location cards. Locations with zero values are ignored, and searching continues serially until five nonzero values are found before a card is punched. The last card may have less than five words. A three-word entry of the type described is again required. Tabulator spacing control is also available.

Indexing accumulator A only, may be used to modify locations to be punched. Accumulators B and C are used internally by the routine.

Basic Read and Punch

Occasionally, use of the preceding reading and punching routines may not be efficient. The alternative is to use the basic Read (70) and Punch (71) operations directly.

When Bell cards are read, the six data words go into the first six locations of the read band. When Random location cards are read, the five data words are put in the first five locations of the read band.

Punching operates in a similar manner. Output format is controlled by the contents of punch band word 10, according to the table in appendix C (III).

Modification of Transcendental Routines

Sine-cosine. - Although the trigonometric routines were designed for arguments in radian measure, conversion of the sine-cosine routines to accept angles in degrees can be made with no increase in storage by changing (1) the word at location 1509 to "90 0000 0052," and (2) the word at location 1478 to "27 7777 7848."

Arctangent. - To convert the arctangent routine for arguments in degrees, (1) change the word at 1643 to "34 9055 1470," (2) add 1469: 57 2957 8052, and (3) add 1470: 39 1469 1496. (Since locations 1469 and 1470 are outside the region used by the package, they must be reserved for this purpose.)

Logarithm. - The logarithm routine was designed for base e. To convert for use with base 10, change the word at 1610 to "69 1609 1671."

RUNNING THE PROBLEM

Preparation of Input

If SOAP II programming is being used, the first pass ("SOAPing") requires loading the SOAP II deck, followed by a 13-card "Synonym" deck, followed by the program. The "Synonym" deck contains the mnemonic location of each package routine with its equivalent absolute drum address, and one Block Reserve (BLR) card reserving the package drum area (1471-1999). The output from this pass will be basic instructions in the form of one-word-per-card self-loading cards. At this time, the deck may be put through a second pass, condensing it to five words per card in Random location format, by use of a 38-word "Shrinko" deck. Shrinking will be discussed in section on "AUXILIARY ROUTINES."

If basic programming is used, the program may be conveniently keypunched in Random-location-card format to begin with.

Execution of Problem

With the standard console setting "70 1951 1998," the package is now loaded into the 653, followed by a "clearing" routine, which in turn is followed by the program. Transfer of control to the first instruction of the program may now be accomplished by console-switching, using a one-word basic load-hub card (00 0000 XXXX), or using a Bell transfer card. A Bell transfer card has a zero word count in column 10. Its execution causes control to be transferred to the location given in columns 6 to 9 after the Bell card number is reset to zero and the problem number is read from columns 5, 78, 79, and 80.

Tracing and Debugging Program

Details on the procedure for tracing are listed in appendix I. Tracing may be started at any point in the program and stopped at any time by turning digit 1 of the storage entry switches from "9" to "8."

The tracing routine is so designed that it will not trace any of the package routines unless desired. If such is the case, change the word at location 1931 to "00 1616 1846."

Trace output is in Bell format containing the following information:

Card column	Contents
1-4	Card number
6-9	Location of instruction
11-21	Instruction
22-32	*Upper accumulator
33-43	*Lower accumulator
44-54	*Distributor
62-65	Indexing register A (sign in col. 55)
68-71	Indexing register B (sign in col. 66)
72-75	Indexing register C (sign in col. 71)
80	"8" Punch (identifies Bell Trace card)

*After execution of instruction.

Debugging is made easier if some sort of drum-core clearing routine is used prior to loading the package and the program. With the drum and core cleared, it is relatively simple to determine if and when control

inadvertently broke out of the program. One of the more commonly used clearing routines sets all unused storages to "STOP" (01) codes (i.e., "01 aaaa 8000," where "aaaa" is the address of the location that has been cleared). (Appendix F contains an example of such a routine.)

ACCURACY AND MATHEMATICAL METHODS

It is important to realize that, in general, computations carried to eight figures cannot be correct to eight figures. Consequently, one must either carry greater precision or accept less accuracy. The 653 has been designed to compute efficiently with eight significant figures in floating point arithmetic, or ten places in fixed point operations. In writing these routines, the advantages of floating point arithmetic have been used to reduce the storage required over that needed for fixed decimal routines, and consequently a reduction in accuracy was accepted. The primary source of this error stems from rounding errors.

All routines are accurate to at least seven significant figures. The authors expect that seven are usually accurate enough for those cases using eight figures for the rest of the computation. If greater accuracy is required, one should obtain a more accurate routine.

SQRT (1750)

The square-root routine uses Newton's iteration method. Rounding errors in trial values sometimes forbid certain digits from being tried in the eighth place; however, the routine does give the closest "tryable" value.

SIN R (1600)

The sine routine yields seven correct figures. Angles requiring reduction (containing multiples of 2π) will be expressed to less than eight significant figures prior to entry into the routine; therefore, corresponding errors in the computed value will result. For many angles, the result is correct to eight figures, but rounding errors forbid this as a generalization. This routine and the one following were adapted from Bell.

COS R (1650)

The cosine is obtained by adding $\pi/2$ to the argument and entering the sine routine. Rounding caused by this addition, and the limitation on the sine routine, determine the accuracy.

EXP10 (1810)

The antilog base 10 is obtained after separating the characteristic and the mantissa. The value of the antilog is obtained from the mantissa by a polynomial taken from the Bell routine. The number of significant figures in the mantissa is reduced by the number of figures in the characteristic. The value of the exponent is computed from the value of the characteristic. The same number of significant figures is obtained for the answer as there are decimal places in the mantissa. Rounding errors affect the eighth figure at times.

EXP E (1800)

The value of exponential e is obtained by dividing by $\log_e 10$ and entering the EXP10 routine. Accuracy is limited by rounding both in this division and by the EXP10 routine.

LNX (1850)

The logarithm base e routine uses a continued fraction which, except for alternating signs, is common with the arctangent routine. These routines are based on those supplied by D. Sweeney of IBM. Accuracy is about ±3 in the eighth figure. When the logarithm is between +0.1 and -0.1, it is accurate to only seven decimal places, since

$$\ln x \rightarrow (x-1)$$
$$x \rightarrow 1$$

It can be seen that as x approaches 1, the value of (x-1) (counting initial zeros) has the same number of figures as x. Since x has not more than eight decimal places when near 1, (x-1) will have not more than eight decimal places, and may well have less than eight significant figures.

ARCTN (1700)

The arctangent routine is accurate to about ±5 in the eighth figure. It necessarily gives the principal angle (i.e., between $-\pi/2$ and $+\pi/2$ radians). The programmer must remember that he might have to add a multiple of π radians to the result.

AUXILIARY ROUTINES

Loading Routine for Package

This 24-word routine loads the package into drum locations 1471 to 1999. It is loaded directly into core from four load-hub cards. The routine is designed to load Random location cards only and can be used to load any "shrunk" program even when the package is not used. In this case, read band 1951-1960 must be reserved and core locations 9030 to 9059 must not be used until after the program is loaded. (See appendix D for a detailed listing of this routine.)

"Shrinko"

A 38-word routine has been devised for condensing SOAP II output from one word per card to five words per card. This condensing routine, called "Shrinko," produces Random location cards with orders located in the sequence they were SOAPed. The routine has been subjected to its own condensing process onto eight Random location cards. A loading deck of seven load-hub cards (using the 533 "Rocket Board") loads "Shrinko" into a table area not disturbing the SOAP II program, so that various programs may be SOAPed and shrunk successively without having to reload the SOAP II deck each time.

In shrinking, SOAP II comments cards, Synonym cards, and other similar type cards are bypassed. A blank card must be placed at the end of the program being shrunk to cause the last card to be processed. If it is desired to have certain sections of a program start on a new card, a blank card must be inserted in the program at this point. (Appendix E lists the "Shrinko" routine in one-word-per-card SOAP II output form.)

(NOTE: Frequently, during the SOAPing pass, the first and last cards of output are meaningless; that is, blanks occur in the positions where card number (cols. 17-20), location (cols. 23-26), and assembled instruction (cols. 31-40) are ordinarily found. To avoid distributor stops in "shrinking" or in direct loading of the unshrunk program, these two cards must be removed.)

Lewis Research Center
National Aeronautics and Space Administration
Cleveland, Ohio, July 13, 1959

APPENDIX A

653 ROCKET PACKAGE

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```
001          SYN SIN R      1600
002          SYN COS R      1630
003          SYN ARCTN      1700
004          SYN SQRT       1750
005          SYN EXP E      1800
006          SYN EXP10      1810
007          SYN LNX        1850
008          SYN RD CK      1900
009          SYN RD LK      1920
010          SYN PUNCH      1930
011          SYN RMPCH      1940
012          SYN LOAD       1950

014          BLR  0000      1470
015          BLR  1841      1844
016          BLR  1941      1949
017          BLR  1998      1999
018          BLR  1990      1990
019          REG B9040      9040
020          REG C9050      9050     CORE
021          REG I1892      1899     INSTRUCTNS
        THAT ARE MOVED TO CORE
023          REG J1991      1996
024          REG K1965      1970
025          REG L1550      1560     1ST L
026          REG O1845      1845     RAND PCH
027          REG P1977      1986     PUNCH BAND
028          REG R1951      1960     READ BAND
029          REG S1872      1880
030          REG T1827      1836
031          REG X1901      1918
032          EQU ONE51     X0016
             EQU HALF       S0009
             SYN AUX         1537
```

SINE COSINE ROUTINE 45 WORDS
REG B AND C BLOCKS IN CORE
AND REG S IS ON DRUM

```
038     COS R STD LINK                          1650   24 1503 1506
039           FAD PI D2     SINB1   ADD 90DEGS  1506   32 1509 1485

041     SIN R STD LINK      SINB1               1600   24 1503 1485

043     SINB1 LDD           STPTR   STOP TRACE  1485   69 1488 1491
044           SET C0001             LD ORDERS   1488   27 9050 1493
045           LDB S0001              ON CORE    1493   09 1872 1475
046           FMP R 2PI             COMPUTE     1475   39 1478 1528
047           STU B0010             REVOLUTION  1528   21 9049 1535
048           FAD EXP58             ROUND OFF   1535   32 1538 1515
049           FSB B0010              INTERGAL   1515   33 9049 1495
050           FAD  8003              PART       1495   32 8003 1525
051           STU B0010             CALC HALFS  1525   21 9049 1483
052           FAD EXP58              IF OVER    1483   32 1538 1565
053           NZU           SINB2    HALF RE-   1565   44 1519 1520
054           BMI SINB3             DUCE ANGLE  1519   46 1472 1473
055           RSU ONE51                         1473   61 1916 1579
056           FAD B0010     SINB4               1579   32 9049 1501
057     SINB2 RSU B0010     SINB4               1520   61 9049 1501
058     SINB3 RAU ONE51                         1472   60 1916 1521
059           FAD B0010     SINB4               1521   32 9049 1501

061     SINB4 FAD  8003             CALC VALUE  1501   32 8003 1481
062           STU B0010              OF SINE    1481   21 9049 1489
063           FAD EXP35                         1489   32 1492 1569
064           FMP  8003              OF ALPHA   1569   39 8003 1523
065           STU B0009              BY SERIES  1523   21 9048 1531
066           LDD  8005                         1531   69 8005 1487
067           STD C0010             SAVE INDXA  1487   24 9059 1543
068           RAA  0004                         1543   80 0004 1499
069           FMP C0005     C0006               1499   39 9054 9055
070     S0006 FAD C0000 A   C0007               1877   32 9249 9056
071     S0007 SXA  0001     C0008               1878   51 0001 9057
```

```
072      S0008 NZA C0009     SINB5                    1879   40 9058 1533
073      S0009 FMP B0009     C0006                    1880   39 9048 9055
074      SINB5 FMP B0010                              1533   39 9049 1486
075            FAD B0010                              1486   32 9049 1615
076            RAA C0010     LINKT    RESTOR IXA      1615   80 9059 1573


079      S0001  57  0796      3350    FOR 1ST          1872   57 0796 3350
080      S0002 -64  5963      7150        3RD          1873  -64 5963 7150
081      S0003  79  6896      7949        5TH          1874   79 6896 7949
082      S0004 -46  7376      5648        7TH          1875  -46 7376 5648
083      S0005  15  1484      1947        9TH          1876   15 1484 1947
                POWER OF ALPHA
085            EQU PI2       PI D2
086      R 2PI  15  9154      9450    1 OVER PI2       1478   15 9154 9450
087      EXP35  00  0000      0035                     1492   00 0000 0035
088      EXP58  00  0000      0058                     1538   00 0000 0058
089      PI D2  15  7079      6351                     1509   15 7079 6351
```

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```
EXPONENTIAL ROUTINE 61 WORDS
USES 9040 TO 9059
091     EXP E STD LINK                EXPO      1800   24 1503 1606
092           FMP EX1       EXB1      NENTIAL   1606   39 1609 1659
093     EX1    43  4294      4850     ENTRY     1609   43 4294 4850
094     EXP10 STD LINK      EXB1                1810   24 1503 1659
095     EXB1  LDD           STPTR               1659   69 1512 1491
096           SET  9043                         1512   27 9043 1517
097           LDB X0001                         1517   09 1901 1504
098           STU  9040                         1504   21 9040 1511
099           FSB  9043                         1511   33 9043 1541
100           BMI          EXB2                 1541   46 1494 1545
101           FAD  9043                         1494   32 9043 1623
102           NZU          EXB61                1623   44 1477 1578
103           FAD  9043                         1477   32 9043 1507
104           BMI EXB3                          1507   46 1510 1561
105           RAU  9040                 EXPONENT 1561   60 9040 1619
106           BMI          EXB4         MINUS    1619   46 1522 1673
107           LDD EX2      EXB5         YES      1522   69 1575 1628
108     X0001  48   9999     9952      FIFTY-1   1901   50 0000 0052
109     EXB2  LDD  8666     EXB3      ALARM     1545   69 8666 1510
110     EXB3  RAU  8002     LINKT     ZERO      1510   60 8002 1573
111     EXB61 RAU  9040                         1578   60 9040 1585
112           FDV EX1                           1585   34 1609 1709
113           FAD  9058     LINKT               1709   32 9058 1573
114     EXB4  RSU  8003                 NO      1673   61 8003 1581
115           STU  9040                         1581   21 9040 1539
116           LDD EX3      EXB5                 1599   69 1542 1628
117     EXB5  STD  9041                 FIND      1628   24 9041 1484
118           FAD HALF                          1484   32 1949 1513
119           UFA EXP58     9049      LAMBDA    1513   02 1538 9049
120     X0007 STU  9042                         1907   21 9042 1665
121           FAD  8002     9050                1665   32 8002 9050
122     X0008 FAM  9040                         1908   37 9040 1587
123           STU  9040                         1587   21 9040 1595
124           LDD  8005                 SAVE      1595   69 8005 1601
125           STD  9043                 INDXA     1601   24 9043 1607
126           RSA  0007                         1607   81 0007 1563
127           RAU  8002     9059                1563   60 8002 9059
128     X0017 FMP  9040     9044                1917   39 9040 9044
129     X0002 FAD  9258     9045                1902   32 9258 9045
130     X0003 NZA  9046     9047                1903   40 9046 9047
131     X0004 AXA  0001     9059                1904   50 0001 9059
132     X0005 FMP  8003     9048                1905   39 8003 9048
133     X0006 STU  9040     EXB6                1906   21 9040 1613
```

```
134     EXB6   RAA   9043                          1613   80 9043 1571
135            RSU   9042                          1571   61 9042 1479
136            SRT   0002                          1479   30 0002 1635
137            RAU   8003                          1635   60 8003 1593
138            AUP   9040                          1593   10 9040 1651
139            STU   9040     9041                 1651   21 9040 9041
140     EX2    RAU   9058                          1575   60 9058 1583
141            FDV   9040     LINKT                1583   34 9040 1573
142     EX3    RAU   8001     LINKT                1542   60 8001 1573
143     HALF    50   0000      0050                1949   50 0000 0050
144     X0009   93   2642      6747                1909   93 2642 6747
145     X0010   25   5491      8048                1910   25 5491 8048
146     X0011   17   4211      2049                1911   17 4211 2049
147     X0012   72   9517      3749                1912   72 9517 3749
148     X0013   25   4393      5750                1913   25 4393 5750
149     X0014   66   2730      8850                1914   66 2730 8850
150     X0015   11   5129      2851                1915   11 5129 2851
151     X0016   10   0000      0051                1916   10 0000 0051
```

SQUARE ROOT ROUTINE 25 WORDS

```
155            REG S1941     1949
156            EQU STOP      L0005
157      SQRT  STD LINK                              1750   24 1503 1656
158            LDD           STPTR                   1656   69 1759 1491
159            BMI STOP                              1759   46 1554 1663
160            NZE           LINKT                   1663   45 1516 1573
161            STU C0000                             1516   21 9049 1723
162            SET C0001                             1723   27 9050 1678
163            LBB S0001                             1678   08 1941 1544
164            SRT  0002               CUTOFF EXP    1544   30 0002 1701
165            RAU  8002                             1701   60 8002 1809
166            MPY 00050               HALF EXP      1809   19 1562 1482
167            SUP  8002               SAVE DEC      1482   11 8002 1591
168            AUP 1ST E                             1591   10 1594 1549
169            ALO  8002     C0001                   1549   15 8002 9050
170      S0001 STU C0010     C0002                   1941   21 9059 9051
171      S0002 RAU C0000     C0003   GET N           1942   60 9049 9052
172      S0003 FDV C0010     C0004   DIV BY R        1943   34 9059 9053
173      S0004 FAD C0010     C0005   ADD R TO Q      1944   32 9059 9054
174      S0005 FMP C0009     C0006   DIV BY 2        1945   39 9058 9055
175      S0006 SUP C0010     C0007   TEST FOR        1946   11 9059 9056
176      S0007 NZE C0008              END            1947   45 9057 1751
177            RAU C0010     LINKT                   1751   60 9059 1573
178      S0008 AUP C0010     C0001                   1948   10 9059 9050
179      S0009  50  0000      0050   ONE HALF        1949   50 0000 0050

181       0050  00  0000      0050                   1562   00 0000 0050
182      1ST E  70  0000      0025                   1594   70 0000 0025
```

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CB-3 back

```
ARCTAN ROUTINE
185      ARCTN STD LINK                                  1700   24 1503 1706
186            LDD           STPTR                      1706   69 1859 1491
187            NZU           LINKT                      1859   44 1713 1573
188            STU C0006                  SIGN ON X     1713   21 9055 1621
189            RAM  8003                                1621   67 8003 1529
190            RAU  8002                                1529   60 8002 1637
191            STD C0003                  ABS VAL X     1637   24 9052 1643
192            FDV C0006                  OVER          1643   34 9055 1496
193            STU C0005                  X IN C0005    1496   21 9054 1603
194            RAU C0003                                1603   60 9052 1611
195            SRT  0002                  EXPONENT      1611   30 0002 1567
196            AUP  8002                  ON FRONT      1567   10 8002 1625
197            RAU  8003                                1625   60 8003 1633
198            TLU L0001                                1633   84 1550 1505
199            ALO            8002                      1505   15 1508 8002
200            RAL  0005      8002        MASK          1508   65 0005 8002
201      L0006 RAU C0006      LINKT                     1555   60 9055 1573
202      L0007 RAU C0003                                1556   60 9052 1763
203            LDD  8002      ARC1                      1763   69 8002 1669
204      L0008 RAU C0003                  FIND          1557   60 9052 1715
205            FAD K4                     X MINUS 1     1715   32 1518 1645
206            STU C0004                  OVER          1645   21 9053 1653
207            RAU C0003                  X PLUS 1      1653   60 9052 1661
208            FSB K4                                   1661   33 1518 1695
209            FDV C0004                                1695   34 9053 1498
210            LDD PI4        ARC1                      1498   69 1801 1669
211      L0009 RSU K4                     FIND MINUS    1558   61 1518 1773
212            FDV C0003                  1 OVER X      1773   34 9052 1476
213            LDD PI D2      ARC1                      1476   69 1509 1669
214      L0010 RSU K4                     FIND          1559   61 1518 1823
215            FDV C0003                  PI OVER 2     1823   34 9052 1526
216            FAD PI D2      ARC2        MINUS         1526   32 1509 1605
217      ARC1  STD C0001                  1 OVER X      1669   24 9050 1675
218            STU C0003      COM                       1675   21 9052 1683

ARCTAN ROUTINE CONSTANTS
221      PI D2  15  7079       6351                     1509   15 7079 6351
222      PI4    78  5398       1650                     1801   78 5398 1650
223      L0001  47  2500       0000        PT 00025     1550   47 2500 0000
224      L0002  50  4142       1356        SQRT2   1    1551   50 4142 1356
225      L0003  51  2414       2136        SQRT2   1    1552   51 2414 2136
226      L0004  53  1500       0000        150          1553   53 1500 0000
227      L0005  99  9999       9999        UPPER LMT    1554   99 9999 9999
```

```
LN X ROUTINE FOR 653
232     LNX   STD LINK                                1850   24 1503 1756
233           LDD          STPTR                      1756   69 1610 1491
234           LDD X0016                               1610   69 1916 1671
235           STD C0005                               1671   24 9054 1527
236           NZU          L0005                      1527   44 1631 1554
237           BMI L0005                               1631   46 1554 1685
238           SRT  0002              EXPON IN         1685   30 0002 1641
239           ALO EXP52              LO PUT IN        1641   15 1644 1599
240           STL C0001              FLT NOTATN       1599   20 9050 1806
241           SLO  8001              CLEAR LO         1806   16 8001 1813
242           ALO 51EXP              NUM IN UPR       1813   15 1566 1721
243           SLT  0002              ADD 51 EXP       1721   35 0002 1577
244           STU C0002                               1577   21 9051 1735
245           RAU C0001              SUB 51 FRM       1735   60 9050 1693
246           FSB 51LNK              EXPONENT         1693   33 1546 1923
247           FMP LN10               MUL LN 10        1923   39 1576 1626
248           FAD LN3                ADD LN  3        1626   32 1629 1655
249           STU C0001                               1655   21 9050 1863
250           RAU C0002                               1863   60 9051 1771
251           FAD K                  X MINUS 3        1771   32 1474 1851
252           STU C0003              OVER             1851   21 9052 1660
253           RAU C0002              X PLUS  3        1660   60 9051 1617
254           FSB K                                   1617   33 1474 1502
255           FDV C0003              EQUALS Y         1502   34 9052 1705
256           FAD  8003              FORM 2Y          1705   32 8003 1785
257           ALO  8001              Y IN LOWER       1785   15 8001 1743
258           STU C0003              2Y IN 9003       1743   21 9052 1602
259           RSU  8002    COM       MINUS Y IN       1602   61 8002 1683
                         UPPER
LN X ROUTINE CONSTANTS
262     EXP52  00  0000     0052                     1644   00 0000 0052
263     51EXP  51  0000     0000                     1566   51 0000 0000
264     51LNK  51  0000     0052                     1546   51 0000 0052
265     K      30  0000     0051                     1474   30 0000 0051
266     LN10   23  0258     5151                     1576   23 0258 5151
267     LN3    10  9861     2351                     1629   10 9861 2351
```

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LN ARCTAN COMMON ROUTINE
272      COM    FMP  8001                    Y SQUARED     1683    39 8001 1536
273             STU  C0002                                 1536    21 9051 1793
274             FMP  K1                                    1793    39 1596 1646
275             FAD  K2                                    1646    32 1649 1725
276             FMP  C0002                                 1725    39 9051 1728
277             FAD  K3                    FORM            1728    32 1681 1657
278             FMP  C0002                 NUMERATOR       1657    39 9051 1710
279             FAD  K4                                    1710    32 1518 1745
280             STU  C0004                                 1745    21 9053 1703
281             RAU  C0002                                 1703    60 9051 1711
282             FMP  K5                                    1711    39 1514 1564
283             FAD  K6                                    1564    32 1667 1694
284             FMP  C0002                                 1694    39 9051 1497
285             FAD  K7                    FORM            1497    32 1500 1627
286             FMP  C0002                 DENOMNATOR      1627    39 9051 1480
287             FAD  K4                                    1480    32 1518 1795
288             FDV  C0004                 QUOTIENT        1795    34 9053 1548
289             FMP  C0003                 MULT BY 2Y      1548    39 9052 1652
290             FAD  C0001      ARC2                       1652    32 9050 1605
291      ARC2   FMP  C0005      LINKT                      1605    39 9054 1573

COMMON CONSTANTS
294      K1     81  5850        8249      DENOM 4          1596    81 5850 8249
295      K2     73  4265        7350      DENOM 3          1649    73 4265 7350
296      K3     16  1538        4651      DENOM 2          1681    16 1538 4651
297      K4     99  9999        9950                       1518    99 9999 9950
298      K5     17  0496        1749      NUM   4          1514    17 0496 1749
299      K6     39  5804        2050      NUM   3          1667    39 5804 2050
300      K7     12  8205        1351      NUM   2          1500    12 8205 1351
```

```
RESERVATIONS FOR INPUT OUTPUT
TO BE USED IN PACKAGE ASSEMBLY

305             REG L1841      1844
306             EQU JOOON      1990
307             EQU TESTC     L0001
TRACE ROUTINE
STORAGE ASSIGNMENTS
310             EQU PBAND      T0001     PUNCH BAND
311             EQU LOC        T0007
312             EQU INST       T0001
313             EQU UPPER      T0002
314             EQU LOWER      T0003
315             EQU DIST       T0004
316             EQU INDXA      T0005
317             EQU INDXB      T0008
318             EQU INDXC      T0006
319             EQU WD CD      T0009
320             EQU CD NO      T0010

8000: 00 LOC 1999 CONSOLE SETTNG
323       1999 STD DIST                  STORE 800X  1999   24 1830 1733
324            STL LOWER                              1733   20 1829 1532
325            STU UPPER                              1532   21 1828 1731
326            RAM  8000               FIND LOC       1731   67 8000 1589
327            SRT  0004                FROM 8000     1589   30 0004 1699
328            STL I ADD                STORE I       1699   20 1753 1856
329            LDD XSTTR               ADDRESS        1856   69 1760 1963
330            STD ST TR      P4       TRACE EXIT     1963   24 1616 1719
331      PCH T STD DIST       PCHTT    STORE 800X     1702   24 1830 1783
332      PCHTT STL LOWER                              1783   20 1829 1582
333            STU UPPER                              1582   21 1828 1781
334            LDD  8005                              1781   69 8005 1687
335            STD INDXA               STORE INDX     1687   24 1831 1534
336            LDD  8006               ACCUM          1534   69 8006 1490
337            STD INDXB                              1490   24 1834 1737
338            LDD  8007                              1737   69 8007 1744
339            STD INDXC      PCH2T                   1744   24 1832 1885
340      PCH2T PCH PBAND      P4       PCH TRACE      1885   71 1827 1719
341      P4    LDD  8000               IF CONSOLE     1719   59 8000 1775
342            BD1 TRHLT                1998 EXIT     1775   91 1778 1530
343            LDD I ADD               FROM TRACE     1530   69 1753 1707
344            STD LOC                 SAVE LOC       1707   24 1833 1586
345            RAU CD NO               NUMBER CD      1586   60 1836 1691
346            AUP ONE D                              1691   10 1794 1749
```

```
347             STU CD NO     P5 TR                  1749   21 1836 1639
348      P5 TR  RAM I ADD                CARD        1639   67 1753 1757
349             SLT  0004               GET NEXT     1757   35 0004 1717
350             ALO XORD                INSTR        1717   15 1570 1825
351             STL INST                             1825   20 1827 1580
352             RAU UPPER               LOAD 800X    1580   60 1828 1883
353             ALO LOWER     ST TR     CASE NEXT    1883   15 1829 1616
354      ST TR  LDD DIST      INST      IS IN 8007   1616   69 1830 1827
INSTR AT NEXT2 PTR
356      PTR    STD INST                LOAD NEW     1752   24 1827 1630
357             LDD  8003                ORDER       1630   69 8003 1636
358             SIA I ADD               STORE I AD   1636   23 1753 1807
359             SLO  8001               CLEAR I AD   1807   16 8001 1765
360             ALO XIADD               ADD NEW IA   1765   15 1568 1973
361             STL ALTER     P3        STOW ALTER   1973   20 1677 1680
362      P3     SLO X50                  INSTR       1680   16 1933 1787
363             BMI           P3        TEST FOR B   1787   46 1540 1680
364             ALO X10                  IF SO ALT   1540   15 1696 1802
365             BMI NONBR                DATA ADDR   1802   46 1755 1857
BRANCH ORDERS
367             RAL ALTER                            1857   65 1677 1881
368             LDD  8003                            1881   69 8003 1588
369             SDA D ADD               STORE D AD   1588   22 1741 1746
370             SLO  8001               CLEAR D AD   1746   16 8001 1803
371             ALO XDADD               ADD NEW DA   1803   15 1608 1614
372             STL ALTER     NONBR     STORE ALTR   1614   20 1677 1755
373      NONBR  RAU UPPER               RESTOR UPR   1755   60 1828 1584
374             ALO LOWER               EXCUTE ORD   1584   15 1829 1634
375             LDD DIST      ALTER                  1634   69 1830 1677
ALTER OP DATA PCH T
IF BRANCH OCCURS GO TO DATA
378      DATA   RAL D ADD               SUBSTITUTE   1852   65 1741 1796
379             SRT  0004               D ADD FOR    1796   30 0004 1658
380             STL I ADD     PCH2T       I ADD      1658   20 1753 1885

DEFINITIONS
383      TRHLT  LDD DIST      I ADD     STOP TRACE   1778   69 1830 1753
384      XSTTR  LDD DIST      INST                   1760   69 1830 1827
385      XORD   RAM  0000     PTR                    1570   67 0000 1752
386      XIADD  00   0000     PCH T                  1568   00 0000 1702
387      XDADD  00 DATA        0000     DATA IS LO   1608   00 1852 0000
OF ROUTINE FOR BRANCH ORDERS
389      X50    50   0000      0000                  1933   50 0000 0000
390      X10    10   0000      0000                  1696   10 0000 0000
```

```
391     CD NO  08  0000      0000     KEY CONTRL   1836    08 0000 0000
FORMAT OF TRACE CARDS
393     WD CD  00  0007      0008                  1835    00 0007 0008

ENTER TRACE IF CONSOL P1 IS 9
AND EXECUTE THE ORDER AT LINK
IN EITHER CASE

399     LINKT LDD  8000                IS CONSOL   1573    69 8000 1679
400           BD1 LINK                 XX XXXX XX  1679    91 1503 1684
401           STD DIST                             1684    24 1830 1734
402           LDD XSTTR                            1734    69 1760 1664
403           STD ST TR                            1664    24 1616 1769
404           LDD XLINK                 SET INST   1769    69 1572 1925
405           STD I ADD    PCHTT      ENTR TRACE   1925    24 1753 1783
406     XLINK  00  0000    LINK                    1572    00 0000 1503

408     STPTR STD NEXTI                            1491    24 1846 1799
409           LDD TRHLT                            1799    69 1778 1931
410           STD ST TR    NEXTI                   1931    24 1616 1846
```

INPUT OUTPUT ROUTINE

```
415       8000  70   1951      1998     CONSOL SET   8000   70 1951 1998
416       AUX   70   1951      1998     AUX ENTRY    1537   70 1951 1998
417       1998  RAA  0000               CLEAR INDX   1998   80 0000 1604
418             RAB  0000                 ACCS       1604   82 0000 1860
419             RAC  0000      LD1                   1860   88 0000 1622
420       LD1   SET  C0007                           1622   27 9056 1727
421             LBB  I0003                           1727   08 1894 1547
422             SET  C0007               CHANGE 2    1547   27 9056 1853
423             LBB  I0007     WCT                   1853   08 1898 1654
LOADED PART OF PROGRAM IN CORE

426       WCT   RAU  R0010     C0007                 1654   60 1960 9056
          C0007 BMI  RLOAD     BELL
428       RLOAD RSL   8003                           1704   66 8003 1761
429             LDD   8003                           1761   69 8003 1618
430             SDA  R0010               FIX WD 10   1618   22 1960 1714
431             SLO   8001               CLEAR DADD  1714   16 8001 1821
432             SLT   0004               SHIFT LEF3  1821   35 0004 1632
433             STL  WDCT      ENTER     WORD COUNT  1632   20 1837 1590
434       1     RAL  XRAL                            1754   65 1708 1764
435             ALO  WDMVD      8002     WORD MOVED  1764   15 1767 8002
436        8002 RAL  R0006     2                     8002   65 1956 1811
437       2     ALO  XSTD                            1811   15 1814 1869
438             AUP  XLDD                            1869   10 1672 1777
439             AUP  WDMVD      8003                 1777   10 1767 8003
440        8003 LDD  R0001      8002                 8003   69 1951 8002
441        8002 STD  LOC       TEST1                 8002   24 1833 1686
442       TEST1 RAU  WDMVD                           1686   60 1767 1871
443             AUP  ONE D     ENTER                 1871   10 1794 1590
444       ENTER STU  WDMVD                           1590   21 1767 1620
445             SUP  WDCT                            1620   11 1837 1791
446             NZU  1         C0008                 1791   44 1754 9057
447       ONE D  00   0001      0000                 1794   00 0001 0000
448       XRAL  RAL  R0006     2                     1708   65 1956 1811
449       XSTD  STD   0000     TEST1                 1814   24 0000 1686
450       XLDD  LDD  R0001      8002                 1672   69 1951 8002

452       BELL  NZU  READ2               IS WCT  0   1804   44 1758 1666
YES GO START PROBLEM                     CLEAR CARD
453             STU  CARDN                 NUMBER    1666   21 1819 1808
454             LDD  R0008               STORE PROB  1808   69 1958 1861
455             STD  PROB                  NUMBER    1861   24 1864 1817
456             RAU  R0007                           1817   60 1957 1961
```

```
457             SRT  0004                          1961    30 0004 1921
458             STO LINK      LINKT    CK FOR      1921    21 1503 1573
                      TRACE
460     RD CK STD LINK                 ENTER TO    1900    24 1503 1858
  READ BELL CARDS CHECKING
462             LDD XRDCK     INTLO                1858    69 1612 1815
463     XRDCK    08 I0003     CHECK                1612    08 1894 1597

INTLO IS ROUTINE TO INTERPRET
 THE CONTENTS OF THE LOWER AND
 IS COMMON TO ALL INPUT OUTPUT

469     INTLO STD RLINK                            1815    24 1668 1971
470           LDD             STPTR    STOP TRACE  1971    69 1524 1491
471           LDD  8003                            1524    69 8003 1730
472           SDA C0005                1ST WORD    1730    22 9054 1736
473           SLT  0004                            1736    35 0004 1647
474           SDA C0006                NUMBER WDS  1647    22 9055 1854
475           SRT  0002                            1854    30 0002 1662
476           RAU  8003                            1662    60 8003 1919
477           SRT  0002                            1919    30 0002 1975
478           SET C0007     RLINK                  1975    27 9056 1668

ORDERS THAT ARE MOVED TO CORE
FOR EXECUTION READ LOAD PUNCH
482     I0001  00  0000     CHECK    C0009 RDLK  1892    00 0000 1597
483     I0002 LDD C0008     BELL     C0010 RDLK  1893    69 9057 1804
484     I0003 BMI C0008     BELL     C0007 RD    1894    46 9057 1804
485     I0004 RAU C0006     RD2      C0008 RD    1895    60 9055 1805
486     I0005 HLT  0002     I0005    C0009 RDCK  1896    01 0002 1896
487     I0006 HLT  0003     I0006    C0010 RDCK  1897    01 0003 1897
488     I0007 BMI RLOAD     BELL     C0007 LD    1898    46 1704 1804
489     I0008 RCD R0001     WCT      END BANDLD  1899    70 1951 1654

COMMON TO READ LOOK AND CHECK
492     CHECK RAU C0005     READ                 1597    60 9054 1855
493     READ  RCD R0001                          1855    70 1951 1712
494           SUP R0007                CK 1ST ADD  1712    11 1957 1762
495           NZE C0009     CK WD                1762    45 9058 1867
496     CK WD RAU C0006                          1867    60 9055 1676
497           SUP R0010                CK TO MANY  1676    11 1960 1865
498           BMI C0010     RDALL       WORDS    1865    46 9059 1670

COMMON TO LOAD LOOK AND CHECK
MOVES THE WORDS
502     RDALL STU C0006                ST NO WDS   1670    21 9055 1927
503           RAU R0010     READ2                  1927    60 1960 1758
```

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CB-4 back

```
504      READ2 AUP R0007                CALC TEST    1758   10 1957 1812
505            STU C0005                 CONSTANT     1812   21 9054 1720
506            AUP XSTD1                              1720   10 1574 1729
507            STU C0004                 IN C0004     1729   21 9053 1887
508            SUP R0010                              1887   11 1960 1716
509            ALO XLDD1     WCT 0                    1716   15 1770 1726
510       8002 LDD R0001      8003                    8002   69 1951 8003
511       8003 STD  0000     RD1                      8003   24 0000 1862
512      RD1   ALO ONE D                               1862   15 1794 1849
513            AUP  8001     WCT 0      TEST FOR      1849   10 8001 1726
514      WCT 0 SUP C0004                 END MOVE     1726   11 9053 1784
515            NZU           C0008                    1784   44 1937 9057
516            AUP  8001      8002                    1937   10 8001 8002

         C0008 RAU C0006     RD2 IF READING
         C0008 RCD R0001     WCT IF LOADING
520      XLDD1 LDD R0001      8003                    1770   69 1951 8003
521      XSTD1 STD  0000     RD1                      1574   24 0000 1862

523      RD2   NZU CHECK     LINKT      GO TO NEXT    1805   44 1597 1573
                          COMMAND

SEEK BELL CD OF CORRECT LOCATN
527      RD LK STD LINK                               1920   24 1503 1962
528            LDD           INTLO                    1962   69 1766 1815
529            LBB I0003     LOOK                     1766   08 1894 1697

533      LOOK  SET C0009                              1697   27 9058 1964
534            LBB I0001     CHECK                    1964   08 1892 1597
535      LK1   STD R0010     CK WD      FIX WD CT     1816   24 1960 1867
536      ONE D  00  0001      0000                    1794   00 0001 0000

538      LOAD  LDD           STPTR      STOP TRACE    1950   69 1560 1491
539            RCD R0001     LD1                      1560   70 1951 1622
LOADS CARD NO CHECK BELL OR
 RANDOM LOCATIONS LOOKS FOR
 TRANSFER CARD
```

```
OUTPUT ROUTINE
PUNCH BELL CARDS

546      PUNCH STD LINK                  START HERE  1930   24 1503 1866
547            LDD PCH1      INTLO                   1866   69 1820 1815
INTLO INTERP LOWER  RETRN PCH1
549      PCH1  LDD WDCT6                             1820   69 1624 1928
550            STD P0009                             1928   24 1985 1638
551            LDD PROB                              1638   69 1864 1718
552            STD P0008                             1718   24 1984 1987
553            LDD C0005     PCH3                    1987   69 9054 1747
554      PCH3  STD P0007                             1747   24 1983 1786
555            ALO CARDN                             1786   15 1819 1674
556            ALO ONE D                             1674   15 1794 1768
557            SDA CARDN                             1768   22 1819 1722
558            STL P0010     NZERO                   1722   20 1986 1689
559      NZERO RAU C0006               IS NO OF      1689   60 9055 1797
560            SUP WDCT6               WORDS LESS    1797   11 1624 1779
561            BMI LESS6     PCH4                    1779   46 1682 1884
562      PCH4  STU C0006                             1884   21 9055 1891
563            RAU P0009                             1891   60 1985 1739
564            SRT  0004                             1739   30 0004 1818
565            AUP XMOVE                 SET TO MOV  1818   10 1772 1929
566            ALO XLOC                   N WORDS    1929   15 1732 1688
567            ALO C0005     MOVEW                   1688   15 9054 1847
568      MOVEW AUP 09999      8002                    1847   10 1868 8002
569       8002 LDD LOC        8003                    8002   69 1833 8003
570       8003 STD P0007      J000N                   8003   24 1983 1990
571      J0000 RAU C0006     PCH2                     1990   60 9055 1997
572      J0001 RAU C0006     PCH2                     1991   60 9055 1997
573      J0002 ALO ONE D     MOVEW                    1992   15 1794 1847
574      J0003 ALO ONE D     MOVEW                    1993   15 1794 1847
575      J0004 ALO ONE D     MOVEW                    1994   15 1794 1847
576      J0005 ALO ONE D     MOVEW                    1995   15 1794 1847
577      J0006 ALO ONE D     MOVEW                    1996   15 1794 1847
578      PCH2  PCH P0001                              1997   71 1977 1780
579            NZE           LINKT     IS IT DONE     1780   45 1934 1573
580            RAU P0007                              1934   60 1983 1738
581            AUP P0009                              1738   10 1985 1789
582            STU C0005     PCH3                     1789   21 9054 1747
```

```
584      LESS6  RAL  C0006                          1682   65 9055 1839
585             STD  P0009                          1839   24 1985 1788
586             SRT   0004          CLEAR ZERO      1788   30 0004 1870
587             ALO  XCLER    8002                  1870   15 1724 8002
588      K0001  STU  P0001   K0002                  1965   21 1977 1966
589      K0002  STU  P0002   K0003                  1966   21 1978 1967
590      K0003  STU  P0003   K0004                  1967   21 1979 1968
591      K0004  STU  P0004   K0005                  1968   21 1980 1969
592      K0005  STU  P0005   K0006                  1969   21 1981 1970
593      K0006  STU  P0006   PCH4                    1970   21 1982 1884

595      XCLER   00   0000   K0001                  1724   00 0000 1965
596      WDCT6   00   0006    0000                  1624   00 0006 0000
597       9999   00   0000    9999                  1868   00 0000 9999
598      XLOC   LDD   0000    8003                  1732   69 0000 8003
599      XMOVE  STD  P0000   J0001                  1772   24 1976 1991
600             EQU  LOC      0000
```

OUTPUT ROUTINE
RANDOM LOCATION CARDS WITH
ZERO VALUES OMITTED

```
605     RMPCH STD LINK                              1940   24 1503 1822
606           LDD  8006          SAVE INDEX        1822   69 8006 1782
607           STD C0003           ACC B AND        1782   24 9052 1838
608           LDD  8007           C                1838   69 8007 1598
609           STD C0004                            1598   24 9053 1922
610           RAC  8002          NO OF WDS         1922   88 8002 1882
611           LDD          INTLO IN C              1882   69 1935 1815

613           LBB L0001          C0004 IS          1935   08 1841 1648
614           STL C0006           COL 80           1648   20 9055 1972
615           RSB  0004           LOCATION         1972   83 0004 1932
616           RAL C0005                            1932   65 9054 1889
617           ALO PCHX      ENT1 C0003 IS          1889   15 1592 1698
618     ENT1  STL C0005           CURRENT          1698   20 9054 1774
                    LOCATION
620           ALO XRAU     8002                    1774   15 1886 8002
621      8002 RAU LOC      00001                   8002   60 0000 1845
622     00001 NZU MOVER     C0007 C0007 HAS        1845   44 1824 9056
       TESTC EQU L0001
624     TESTC SXC  0001                            1841   59 0001 1748
625           NZC          FINS                    1748   48 1924 1974
626           RAL C0005                            1924   65 9054 1936
627           ALO ONE D     ENT1                   1936   15 1794 1698

629     MOVER STD P0005 B          MOVE WD         1824   24 5981 1888
630           RAL C0005                            1888   65 9054 1798
631           STD P0010 B                          1798   24 5986 1939
632           NZB          PCH5  IS CARD          1939   42 1642 1848
633           AXB  0001     C0007  FULL YET       1642   52 0001 9056
634     PCH5  BMI          PLUS                    1848   46 1776 1826
635           SLO C0006     BOTH FIX COL 80        1776   16 9055 1938
636     PLUS  ALO C0006     BOTH                   1826   15 9055 1938
637     BOTH  STL P0010                            1938   20 1986 1989
638           RAL RMCDN          NUMBER CDS        1989   65 1692 1926
639           ALO ONE I                            1926   15 1988 1976
640           STL RMCDN                            1976   20 1692 1640
641           LDD P0009                            1640   69 1985 1690
642           SIA P0009                            1690   23 1985 1740
```

```
643             PCH P0001                PUNCH CARD   1740   71 1977 1790
644             RSB  0004     C0008     C0008 HAS    1790   83 0004 9057
645     L0002   STU C0006     C0007       L0002      1842   21 9055 9056

647     ONE I    00  0000      0001     ONE INSTR    1988   00 0000 0001
648     XRAU     59  9999     02001                  1886   59 9999 3845
649     PCHX     00  0000      8000                  1592   00 0000 8000
650     RMCDN    00  0000       000     RANDOM CD    1692   00 0000 0000
                    NUMBER
652     FINS    SET C0007                CHANGE       1974   27 9056 1840
653             LBB L0003                 ORDERS      1840   08 1843 1890
654             RSL PCHX                  FOR FINS    1890   66 1592 1742
655             STL C0005     C0007                  1742   20 9054 9056
656     L0003   LDD  8003     MOVER                  1843   69 8003 1824
657     L0004   RAB C0003                RESTOR       1844   82 9052 1792
658             RAC C0004     LINKT       INDX ACC    1792   88 9053 1573
```

APPENDIX B

TABLE OF ROUTINES

Mnemonic entry	Drum entry	Number of drum storages used	Core storages used	Execution time,[a] millisecs
SIN R	1600	45	9048-9059	145 (192)
COS R	1650		9048-9059	145 (192)
EXP E	1800	61	9040-9059	190 (197)
EXP10	1810		9040-9059	160 (187)
LNX	1850	102	9050-9054	174 (202)
ARCTN	1700		9050-9055	190 (238)
SQRT	1750	25	9049-9059	140 (206)
RD CK	1900	93	9050-9059	(b)
RD LK	1920		9050-9059	(b)
LOAD	1950		9050-9059	(b)
	1998		9050-9059	(b)
PUNCH	1930	51	9050-9059	(c)
RMPCH	1940	48	9050-9059	(c)

[a]Times in parentheses are for comparable Bell 650 routines.

[b]533 Read-Feed limited (200 cards per min).

[c]533 Punch-Feed limited (100 cards per min).

APPENDIX C

CARD FORMATS

I. Bell input card format:

Card column	Card contents	Read band contents	
		Word number	Digits used in word
1-4	Card number	9	8-5 (D-address)
[a]5	Part of problem number	8	8
[a]6-9	Location of word 1	7	8-5 (D-address)
10	Word count	10	5
11-21	Word 1 (col. 11 is sign)	1	10-1
22-32	Word 2 (col. 22 is sign)	2	10-1
33-43	Word 3 (col. 33 is sign)	3	10-1
44-54	Word 4 (col. 44 is sign)	4	10-1
55-65	Word 5 (col. 55 is sign)	5	10-1
66-76	Word 6 (col. 66 is sign)	6	10-1
77-79	Problem number	8	7-5
80	Tab. space control	9	9

[a]Columns 5 and 6 must be punched.

Bell output format is the same as input. Information is punched from the same word arrangement as used for reading except that words 9 and 10 are interchanged.

II. Random location input card format:

Card column	Card contents	Read band contents	
		Word number	Digits used in word
1-4	Word 1 location	6	8-5 (D-address)
5-15	Word 1 (col. 15 is sign)	1	10-1
16-19	Word 2 location	7	8-5 (D-address)
20-30	Word 2 (col. 30 is sign)	2	10-1
31-34	Word 3 location	8	8-5 (D-address)
35-45	Word 3 (col. 45 is sign)	3	10-1
46-49	Word 4 location	9	8-5 (D-address)
50-60	Word 4 (col. 60 is sign)	4	10-1
61-64	Word 5 location	10	8-5 (D-address)
65-75	Word 5 (col. 75 is sign)	5	10-1
76-80	(Not read)		

Output format is the same as input, except that the card number is put in word 9 (positions 4 to 1), and column 80 is wired to punch from position 9 of word 10. The first column of any location will be blank if the sign of the location is negative. Thus, to punch out and load back, say two words only, make the sign of word 8 negative. This causes the first column of the third location to be blank, limiting loading to two words.

III. Output is controlled by word 10 of the punch band according to the following table:

X	Output format
1	Sign over units
2	Suppress plus signs
3	Load hub cards
4	Random location cards
9	Bell Trace format
(no "8")	Bell format

"X" is the digit position of an "8" in word 10 of the punch band. For example, if word 10 contained

00 0000 8000

Random location cards would be punched.

APPENDIX D

LOADING ROUTINE FOR ROCKET PACKAGE

(4 Load-Hub Cards)

Card	Location	Operation		Data address	Instruction address	Remarks
		SOAP	Basic			
-	8000		70	1951	1998	Console setting
1	1951	RCD	70	9050	9050	
2	9050	RCD	70	9040	9040	Read load cards 2, 3, and 4
3	9040	RCD	70	9030	9030	
4	9030	RCD	70	1951	9051	Reads package cards
2	9051	RAM	67	1960	9052	Loc "n" & word count in
2	9052	LDD	69	8003	9053	8002
2	9053	SDA	22	1960	9054	Position wdct. to D-addr.
2	9054	SLO	16	8001	9055	of lower & store at 9058
2	9055	SLT	35	0004	9056	
2	9056	STL	20	9058	9057	
2	9057	STU	21	9059	9041	Diminish wdct. Finished
3	9041	SUP	11	9058	9042	storing this card? Yes -
3	9042	NZU	44	9043	9030	Read next package card
3	9043	RAL	65	9031	9044	Storing routine
3	9044	ALO	15	9059	8002	
-	8002	RAL	65	1956	9045	Word location in lower
3	9045	ALO	15	9032	9046	Mask added to lower
3	9046	AUP	10	9033	9047	
3	9047	AUP	10	9059	8003	
-	8003	LDD	69	1951	8002	Word in distributor
-	8002	STD	24	0000	9034	Word location in lower
4	9031	RAL	65	1956	9045	
4	9032	STD	24	0000	9034	Mask
4	9033	LDD	69	1951	8002	
4	9034	RAU	60	9059	9035	
4	9035	AUP	10	9036	9057	
4	9036		00	0001	0000	Constant (=1)

APPENDIX E

ROUTINE FOR LOADING "SHRINKO" DECK

(7 Load-Hub Cards)

Word	Card 1	Card 2	Card 3	Card 4
1	69 1952 1953	70 0111 0111	24 0227 0202	24 0231 0202
2	69 0102 0101	69 0104 0103	69 8003 0234	65 1956 0104
3	24 0111 1954	69 0106 0105	24 0228 0203	24 0232 0203
4	70 0201 0201	69 0108 0107	16 8001 0102	10 0204 0105
5	70 0111 0111	70 0111 0111	24 0229 0204	24 0234 0205
6			20 0233 0202	22 1960 0228
7			24 0230 0205	
8			11 0233 0103	

Word	Card 5	Card 6	Card 7
1	24 0111 1955	66 1960 0227	70 1951 0101
2	70 0201 0201	35 0004 0229	21 0106 0230
3		44 0107 0201	15 0106 8002
4		15 0207 0232	69 1951 8002
5		10 0106 8003	60 0106 0206
6		00 0000 0000	10 0108 0202
7		65 0231 0203	24 0000 0205
8		00 0001 0000	00 0000 0000

In order to minimize reloading of the SOAP II Deck, this loader and the entire Shrinko deck are loaded into disposable locations of SOAP II.

```
001            BLR  0159      1999
002            BLR  0000      0100
003            REG  M0101     0115
004            REG  N0127     0136
005            EQU  N000N     N0000
006            EQU  N005N     N0006

SOAP PACKAGING ROUTINE
NICKNAMED  SHRINKO

011      M0000  70 M0011     M0012     RD COMMAND   0100   70 0111 0112
012      M0011 RAU M0001               IS THIS CD   0111   60 0101 0155
013            SUP XTEST               TO BE LOAD   0155   11 0158 0116
014            NZU M0000               YES RD NXT   0116   44 0100 0120
015            RAL XRPKG     STORE                  0120   65 0123 0137
016      STORE STL LINKP     STORA                  0137   20 0141 0144
017      STORA RAU XSTDV               MODIFY       0144   60 0147 0151
018            AUP ONE D                STOR NUMB    0151   10 0154 0117
019            STU XSTDV                COMMAND      0117   21 0147 0150
020            LDD M0004      8003                   0150   69 0104 8003
021       8003 STD N000N     M0013                  8003   24 0126 0113
022      M0013 AUP XSTDL                             0113   10 0118 0124
023            LDD M0003      8003                   0124   69 0103 8003
024       8003 STD N005N     M0014                  8003   24 0132 0114
025      M0014 SUP XFINS     LINKP                  0114   11 0119 0141
026      XRPKG NZU M0000     M0015                  0123   44 0100 0115
027      M0015 RAL N0010                            0115   65 0136 0142
028            LDD PCONT               WHEN CARD    0142   69 0145 0148
029            SDA N0010     COUNT      IS FULL     0148   22 0136 0139
030      COUNT RAL NUMBR               PUNCH IT     0139   65 0143 0149
031            EQU ONE I     XSTDL
032            ALO ONE I               NUMBER THE   0149   15 0118 0125
033            STL NUMBR                CARDS       0125   20 0143 0146
034            LDD N0009                            0146   69 0135 0138
035            SIA N0009                            0138   23 0135 0140
036            PCH N0001               PUNCH CARD   0140   71 0127 0152
037            LDD XSTD                INITIALIZE   0152   69 0156 0121
038            STD XSTDV     M0000                  0121   24 0147 0100

040      M0012 RSL PCONT               PUT  ZEROS   0112   66 0145 0153
041            STL M0003                IN UNUSED   0153   20 0103 0157
042            STU M0004                OF OUTPUT   0157   21 0104 0122
043            RAL XCLR      STORE                  0122   65 0126 0137

SOAP PACKG ROUTINE DEFINITIONS

047      XTEST  69  1954      1953                  0158   69 1954 1953
048      XSTD  STD N0000     M0013                  0156   24 0126 0113
049      XSTDV  24 N0000     M0013                  0147   24 0126 0113
050      XSTDL  00  0005      0001                  0118   00 0005 0001
051      XFINS  24 N0010     M0014                  0119   24 0136 0114
052      ONE D  00  0001      0000                  0154   00 0001 0000
053      NUMBR  00  0000      000                   0143   00 0000 0000
054      XCLR  NZU STORA     COUNT                  0126   44 0144 0139
```

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APPENDIX F

CLEAR ROUTINE

Word	Load card 1	Load card 2	Load card 3	Load card 4
1	RAU 1955 1952	STU 9259 9001	NZC 9007 8000	RAU 1952 1953
2	RAC 1450 1953	SUP 9005 9002	SXC 0050 9008	HLT 9050 8000
3	RAB 0022 1954	SXA 0001 9003	RAB 0050 9009	RAA 0059 1954
4	RAA 0000 1958	SXB 0001 9004	RAA 0000 9000	STU 9200 1955
5	HLT 1471 8000	NZB 9000 1956		SUP 1956 1957
6	SET 9260 1957	00 0001 0000		00 0001 0000
7	STB 6000 9006	RCD 9006 9006		NZA 1958 1537
8	RCD 9000 9000			SXA 0001 1954

This four-card clear routine clears drum (0000 through 1471) and core (9000 through 9059) to "01 aaaa 8000," where "aaaa" is the address of the particular location cleared.

APPENDIX G

533 CONTROL PANEL ("ROCKET BOARD") WIRING INSTRUCTIONS

I. Read card C is used for reading Bell format cards. The word positions are numbered from the right (see 650 Manual of Operation, p. 10):

Read card C (card column)	Storage entry C	Word size entry C
11-21	Word 1, col. 11 is sign	10
22-32	Word 2, col. 22 is sign	10
33-43	Word 3, col. 33 is sign	10
44-54	Word 4, col. 44 is sign	10
55-65	Word 5, col. 55 is sign	10
66-76	Word 6, col. 66 is sign	10
6-9	Word 7, positions 8 to 5, emit sign +	8
5, 77-79	Word 8, positions 8 to 5, emit sign +	8
80, 1-4	Word 9, positions 9 to 5, emit sign +	9
10	Word 10, position 5, emit sign +	5
	Positions 4 to 1 of words 7, 8, 9, and 10 wired to emit zero	

II. Read card B is used for reading Random location format cards:

Read card B (card column)	Storage entry B	Word size entry B
5-15	Word 1, col. 15 is sign	10
20-30	Word 2, col. 30 is sign	10
35-45	Word 3, col. 45 is sign	10
50-60	Word 4, col. 60 is sign	10
65-75	Word 5, col. 75 is sign	10
1-4	Word 6, positions 8 to 5, emit sign +	8
16-19	Word 7, positions 8 to 5, emit sign +	8
31-34	Word 8, positions 8 to 5, emit sign +	8
46-49	Word 9, positions 8 to 5, emit sign +	8
61-64	Co-selector 1 transferred points (U, 1 to 4) (Location by col. and row corresponds to fig. 51, p. 59 of 650 Manual)	
76-80	Not wired	
	Words 6 to 9 emit zero into positions 4 to 1	

Selector wiring for determining and entering the word count in word 10, and insuring that word 10 is a legitimate word is as follows:

Co-selector 1 common (W, 1 to 4) to word 10, positions 8 to 5, storage entry B
Word size of word 10, entry B, is 8
Co-selector 1 normal (V, 1 to 4) wired to emit digits 8000 (V, 32 and 31). (This guarantees a nonzero value in word 10 to preserve the negative sign for a branch on minus test.)
Emit zeros to word 10, positions 4 to 2, storage entry B
Emit sign of word 10 minus (V, 28)
Pilot selector 1 common (K, 23) to word 10, position 1, storage entry B
Pilot selector 1 normal (J, 23) to emit zero
Pilot selector 1 transferred (H, 23) to pilot selector 2 common (K, 24)
Pilot selector 2 transferred (H, 24) to pilot selector 3 common (K, 25)
Pilot selector 3 normal (J, 25) to emit 2 (W, 21)
Pilot selector 3 transferred (H, 25) to pilot selector 4 common (K, 26)
Pilot selector 4 normal (J, 26) to emit 3 (X, 21)
Pilot selector 4 transferred (H, 26) to pilot selector 5 common (K, 27)
Pilot selector 5 normal (J, 27) to emit 4 (Y, 21)
Pilot selector 5 transferred (H, 27) to emit 5 (Z, 21)
Pilot selector 2 normal (J, 24) to emit 1 (V, 21)
First reading col. 1 (A, 23) to load (B, 21)
First reading col. 1 (A, 23) to col. split (Z, 34)
Col. split 0-9 (Y, 34) to D pick pilot selector 1 (F, 23)

Co-selector 3 pick (R, 25) to col. split X-12 (X, 34)
Co-selector 3 common (W, 11) to emit 9 (W, 34)
Co-selector 3 transfer (U, 11) to entry B (D, 21)

First reading col. 16 (A, 38) to D pick pilot selector 2 (F, 24)
First reading col. 31 (B, 33) to D pick pilot selector 3 (F, 25)
First reading col. 46 (C, 28) to D pick pilot selector 4 (F, 26)
First reading col. 61 (D, 23) to D pick pilot selector 5 (F, 27)
Couple pilot selector 5 (G, 27) to co-selector pickup 1 (S, 23)

Digit impulse (Q, 21) to digit selector common (P, 21)
First reading col. 15 (A, 37) to col. split (X, 33)
Col. split (Z, 33) to entry B (D, 22)

Hold for pilot selectors 1 to 5 (P, 23 to 27) and co-selectors 1 and 3 (U, 23 and 25) are wired to read hold (T, 39).

III. Punch card C is used to punch Bell format cards and Trace format cards:

Punch card C (card column)	Storage exit C
11-21	Word 1, col. 11 is sign
22-32	Word 2, col. 22 is sign
33-43	Word 3, col. 33 is sign
44-54	Word 4, col. 44 is sign
55-65	Word 5, col. 55 is sign
66	Co-selector 7 common (W, 59)
	Co-selector 7 normal (V, 59) to word 6 sign (AG, 64)
67	Word 6, position 10
68-72	Co-selectors 6 & 7 common (W, 54 to 58)
	Co-selectors 6 & 7 normal (V, 54 to 58) to word 6, positions 4 to 1
73-76	Word 6, positions 4 to 1
6-9	Co-selector 6 common (W, 50 to 53)
	Co-selector 6 normal (V, 50 to 53) to word 7, positions 8 to 5
5,77-79	Word 8, positions 8 to 5
10	Word 9, position 5
80,1-4	Word 10, positions 9 to 5

For Trace cards:

Co-selector 6 transfer (U, 50 to 53) to word 7, positions 4 to 1
Co-selectors 6 and 7 transfer (U, 54 to 57) to word 8, positions 4 to 1
Co-selector 7 transfer (U, 58) to word 6, sign position
Co-selector 7 transfer (U, 59) to word 8, sign position

An 8 in position 9 of word 10 causes Trace cards to be punched by means of control information:

Control information (AK, 56) to co-selectors 6 and 7 pick (R, 28, 29)
Co-selectors 6 and 7 hold (T, 28, 29) to punch hold (R, 39)

IV. Punch card B is used to punch Random location cards:

Punch card B (card column)	Storage exit B
5-15	Word 1, col. 15 is sign
20-30	Word 2, col. 30 is sign
35-45	Word 3, col. 45 is sign
50-60	Word 4, col. 60 is sign
65-75	Word 5, col. 75 is sign
1	Pilot selector 6 common (K, 28) Pilot selector 6 normal (J, 28) to word 6, position 8
2-4	Word 6, positions 7 to 5
16	Pilot selector 7 common (K, 29) Pilot selector 7 normal (J, 29) to word 7, position 8
17-19	Word 7, positions 7 to 5
31	Pilot selector 8 common (K, 30) Pilot selector 8 normal (J, 30) to word 8, position 8
32-34	Word 8, positions 7 to 5
46	Pilot selector 9 common (K, 31) Pilot selector 9 normal (J, 31) to word 9, position 8
47-49	Word 9, positions 7 to 5
61	Pilot selector 10 common (K, 32) Pilot selector 10 normal (J, 32) to word 10, position 8
62-64	Word 10, positions 7 to 5
76-79	Word 9, positions 4 to 1
80	Word 10, position 9

Pilot selector 6 I pick (G, 28) to sign word 6
Pilot selector 7 I pick (G, 29) to sign word 7
Pilot selector 8 I pick (G, 30) to sign word 8
Pilot selector 9 I pick (G, 31) to sign word 9
Pilot selector 10 I pick (G, 32) to sign word 10
Co-selector 2 pick (R, 24) to punch X impulse (A, 43)
Co-selector 2 common (W, 6) to punch hold (R, 39)
Co-selector 2 transferred (U, 6) split wire to transfer of pilot selectors 6 to 10 inclusive (L, 28 to 32)
Pilot selectors 6 to 10 common (N, 28 to 32) to pilot selector hold 6 to 10 (Q, 28 to 32)
Co-selector 2 hold (T, 24) to punch hold (S, 39)
Control information 4 (AK, 61) to punch B (D, 43)

V. Punch card A is used to punch Load format cards:

Punch card A (card column)	Storage exit A
1	Col. split common (AM, 52) Col. split 0-9 (AL, 52) to word 1, position 10 Col. split 12-X (AK, 52) to emit 12 (S, 43); wire DI (Q, 43) to common (R, 43)
2-10	Word 1, positions 9 to 1
11-20	Word 2
21-30	Word 3
31-40	Word 4
41-50	Word 5
51-60	Word 6
61-70	Word 7
71-80	Word 8

Control information 3 (AK, 62) to punch A (C, 43)
Control information 2 (AK, 63) to co-selector 5 pick (R, 27)
Control information 1 (AK, 64) to co-selector 8 pick (R, 30)

Co-selector 5 common (W, 45) to punch plus (W, 42)
Co-selector 5 normal (V, 45) to punch plus (V, 42)

Co-selector 8 common (W, 60) to punch sign over units (W, 41)
Co-selector 8 transferred (U, 60) to punch sign over units (V, 41)
Hold co-selectors 5 and 8 (T, 27 and 30) to punch hold

APPENDIX H

TABULATOR SPACING CONTROL

Digit 9 of the specification word used in conjunction with the PUNCH (1930) and RMPCH (1940) routines indicates the number that will be punched in column 80 of the first output card. This digit controls tabulator spacing according to the following table:

Digit in column 80 of output card	Tabulator spacing
0	Print every line.
1	Skip to next sheet before printing.
2	Advance to next half sheet.
3	Advance to next third of a sheet.
4	Advance to next quarter of a sheet.
5	Advance to next fifth of a sheet.
6	Double space between lines.
7	Triple space between lines.
8	Print in Bell Trace format.
9	Print properly spaced comments.

APPENDIX I

OPERATING INSTRUCTIONS

I. Shrinking

A. 533 Read-Punch unit:

1. Insert "Rocket" control panel.
2. Ready read feed with "Shrinko" deck + SOAPed program + blank card.
3. Ready punch feed with blank cards.

B. Set 650 console according to table in this appendix.
C. Press computer reset key.
D. Press program start key.
E. Press end of file key when read hopper empties.

II. Loading Rocket Package and Program (shrunk or unshrunk)

A. 533 Read-Punch unit:

1. Insert "Rocket" control panel.
2. Ready read feed with Rocket Package + drum-core clearing routine (if desired) + program + transfer card.
3. Ready punch feed with blanks.

B. Set 653 console according to table in this appendix.
C. Press computer reset key.
D. Press program start key.
E. Press end of file key when read hopper empties.

Programmed stops:

99 9999 9999: Entering the logarithm routine with zero or negative argument, or entering the square-root routine with a negative argument.

01 0002 1896: Bell card being read by the "Read-Check" routine has location (cols. 6 to 9) different from that in "specification" word.

01 0003 1897: Word count on Bell card (col. 10) being read by "Read-Check" routine is greater than the number of words punched on the card.

Location 1503 contains the next order in the program that was to be executed after the order that caused the stop.

III. Tracing

To start tracing on any instruction, proceed as follows:

A. Set the address of the order at which tracing is to begin in the "Address Selection" switches.
B. Set control switch to "Address Stop."
C. When the machine stops just prior to executing the instruction on which tracing is to begin, set the storage entry switches to

00 XXXX 1999

where XXXX is copied from the address selection lights.
D. Set control switch to "Run."
E. Push "Program Reset" (not "Computer Reset").
F. Push "Start."

(NOTE: Transferring out of tracing to normal program execution may be done at any time by turning digit 1 of the storage entry switches from "9" to "8.")

TABLE

Console Switch Settings for Shrinking

and Rocket Package + Program Loading

Switches	Setting
Storage entry	70 1951 1998
Programmed	Stop
Half cycle	Run
Address selection	(Not set)
Control	Run
Display	Program register
Overflow	Stop
Error	Stop

(NOTE: Before (1) loading the unshrunk program with the rocket package or (2) "Shrinking," make sure the first and last cards are meaningful SOAP II output. This can most easily be verified by seeing that these cards have been assigned a card number (cols. 17 to 20) by the SOAPing pass.)

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